SB4 Model Criteria for Groundwater Monitoring: The Expert Consultation Process

Public Stakeholder Meeting to Develop Groundwater Monitoring Model Criteria for Oil and Gas Areas
December 11, 2014 (Cal/EPA Klamath Room, Sacramento)

Brad Esser (LLNL)

Lawrence Livermore National Laboratory

SB4 Pavley. Oil and gas: well simulation.

Section 7. Groundwater Monitor Plan

- **(a) Groundwater protection**
  — *The Legislature finds and declares that protecting the state's groundwater for beneficial use, particularly sources and potential sources of drinking water, is of paramount concern.*

- **(b) Scientifically-based groundwater monitoring**
  — *The Legislature further finds and declares that strategic, **scientifically based groundwater monitoring** of the state's oil and gas fields is critical to allaying the public's concerns regarding well stimulation treatments of oil and gas wells.*

SB4 explicitly discusses scientifically-based groundwater quality monitoring

Groundwater quality monitoring

Section 7. Groundwater Monitor Plan

- **(c) Development of model groundwater monitoring criteria**

*In order to assess the potential effects of well stimulation treatments on the state's groundwater resources in a systematic way, the State Board **shall develop model groundwater monitoring criteria.***

*The State Board shall prioritize monitoring of groundwater that is or has the potential to be a source of drinking water, but **shall protect all waters designated for any beneficial use**.*

The Water Board is responsible for developing "model criteria" for groundwater quality monitoring

More than one plan required

- **(7c) Development of model groundwater monitoring criteria**
  - *The model criteria shall address a **range of spatial sampling scales** from methods for conducting appropriate monitoring on individual oil and gas wells subject to a well stimulation treatment, to methods for conducting a regional groundwater monitoring program.*

Scale	Responsibility	What
Well by well	Well Operator	Nearby water well
		An individual or small set of oil & gas wells
Regional	SWRCB	Groundwater basin
		Oil & gas field

The threshold for transitioning from well-by-well to regional monitoring is one of the criteria to be developed

Expert advice

Section 7. Groundwater Monitor Plan

- (**d) Requirement for expert advice**
  - *The state board … **shall seek the advice of experts** on the design of the model groundwater monitoring criteria. The experts shall assess and make recommendations to the state board on the model criteria.*

Expert
Lawrence Livermore National Laboratory

Expert Advice

State agency
Water Boards
Staff & Members

Model criteria for groundwater monitoring

REGULATION

The Water Board is responsible for seeking expert advice.

SWRCB has contracted LLNL as an expert advisor

- **Lawrence Livermore National Laboratory**
  - — Helped State develop both Geotracker and the GAMA program
  - — Expertise in characterizing and monitoring the subsurface
    - – aqueous, isotope & gas geochemistry;
    - – groundwater transport & contaminant attribution;
    - – seismology & rock mechanics; computational geoscience
    - – geothermal resources & carbon sequestration;
    - – contaminated site characterization and conceptual models;
    - – environmental monitoring and compliance

Contract PI:	Brad Esser (bkesser @llnl.gov)
LLNL staff scientist	*Technical Lead:* GAMA Special Studies *Group Lead:* LLNL Environmental Radiochemistry Group *Capability Lead:* LLNL Environmental Monitoring Radioanalytical Laboratory

The Water Board has a long relationship with LLNL for its technical expertise

LLNL will use both internal and external expertise

- **LLNL will subcontract experts from other institutions**
  - —LLNL has authority to independently chooses advisors subject to conflict-of-interest review by State Water Board

LLNL will alone be responsible for recommendations and evaluations delivered to the Water Board.

What were we looking for?

- **We were looking for expertise in**
  - —Groundwater monitoring
  - —Groundwater vulnerability
  - —Well construction
  - —Well stimulation mechanics and chemistry
  - —Chemical compound toxicology, transport & analysis

- **We were looking for experience in**
  - —California groundwater basins and oil & gas reservoirs
  - —California oil & gas industry, including WST
  - —Environmental monitoring of WST in other areas

LLNL was looking for expertise and experience

Expert: Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory

Dr. Bradley K. Esser, Lead
LLNL Staff Scientist and Group Leader
GAMA Special Studies Technical Lead

Dr. Joseph Morris
LLNL Computational Geoscience Lead

Dr. Susan Carroll
LLNL Associate Program Lead for
Carbon Management Science

Vic Madrid, PG, CHG
LLNL Site 300 Hydrogeology Lead

Short bios will be on the
SWRCB SB4 website

LLNL is the scientific expert chosen by the State

Experts from LBNL, CSU Bakersfield and Stanford U

Lawrence Berkley National Laboratory

Dr. William T. Stringfellow
Director, LBNL Env. Measurements Lab
Professor & EERP Director, U Pacific

Preston D. Jordan, PG, CHG, CEG
Hydrogeologist and Project Lead

Dr. Harry Beller
Sr Scientist, LBNL
Director, Biofuels Pathways, JBEI
Adjunct Professor, Chemical Engineering &
Applied Chemistry, University of Toronto

California State University, Bakersfield

Dr. Janice Gillespie
Professor of Geology
California State University, Bakersfield

Stanford University

Dr. Rob Jackson
Professor Environmental Earth System Science;
Sr Fellow, Woods Institute for the Environment;
Sr Fellow, Precourt Institute for Energy
Stanford University

The "experts" are not a panel – LLNL alone is responsible for the final report and recommendations.

SB4 Scientific Assessment (CCST/LBL)

- **CCST has recently issued an EIR under contract with BLM**

  — CCST, LBNL and Pacific Institute (2014a) *Advanced Well Stimulation Technologies in California: An Independent Review of Scientific and Technical Information*

- **CCST is working on a SB4 assessment under contract with California DOC**

  — **I. Geology and Well Stimulation Treatments (January 1, 2015):**
  The factual basis describing what well stimulation treatments (WST) are, how they are conducted in general and practiced in California, and where they have been and are being used for oil and gas production in the state.

  — **II. Generic and Potential Environmental Impacts of Well Stimulation Treatments (July 1, 2015):**
  An assessment of the potential impacts of WST with respect to water, air quality, and greenhouse gas emissions, as well as induced seismicity, ecology, traffic and noise.

  — **III. Case Studies with Selected Evaluations of Environmental and Public Health Risk (July 1, 2015)**: Case studies to assess environmental issues and qualitative hazards for specific geographically regions

CCST will release findings beginning in 2015

Timeline

Date & Location	Event	Description
December 2014	**This meeting**	Public & stakeholder input to LLNL and to LLNL technical advisors.
February 2015	**GRA Symposium**	Oil, Gas, and Groundwater in California
March 2015	**Technical workshop**	Presentation of technical issues involved in development of recommendations to Water Board members
March 2015	Draft report to Water Board staff	
April 2015	**Presentation to Water Board Members**	Presentation of recommendations to Water Board members.
May 2015	Final report to Water Board	

The Water Board develops criteria by July 2015.

Operator-Required Groundwater Monitoring

- **Groundwater monitoring & analysis requirements**
  — Laboratory analytical methods?
  — How frequently and how long?

- **Groundwater monitor well design**
  — How many wells? What types of wells?
  — What depth intervals?
  — How close to the stimulated well?
  — What information will be required to support the monitoring design?

- **Data accessibility**
  — What should the requirements be for reporting and data sharing?
  — What other types of information should be required or requested?

- **Limitations or exemptions?**
  — Lack of protected water
  — Significant vertical separation
  — *Presence of hydrocarbon zone or UIC-exempted aquifer*
  — *Presence of unrelated groundwater contamination*

Operator-required groundwater monitoring targets an individual stimulation well or a small number of wells

Operator-Required Groundwater Monitoring: Documents

DOGGR Interim Regulations

SB 4 INTERIM WELL STIMULATION TREATMENT REGULATIONS

TEXT OF PROPOSED REGULATIONS

Added text is shown in underline.

CHAPTER 4. DEVELOPMENT, REGULATION, AND CONSERVATION
OF OIL AND GAS RESOURCES

Subchapter 2. Environmental Protection

Science Assessments

Advanced Well Stimulation Technologies in California

CCST, LBNL and Pacific Institute (2014)
Advanced Well Stimulation Technologies in
California: An Independent Review of
Scientific and Technical Information.,

Stakeholder input

Development & Implementation of
Groundwater Monitoring Criteria
Pursuant to SB4

November 10, 2014

terraphase engineering

CLEAN WATER ACTION   CRPE CENTER ON RACE, POVERTY & THE ENVIRONMENT   CCSC   ENVIRONMENTAL WORKING GROUP
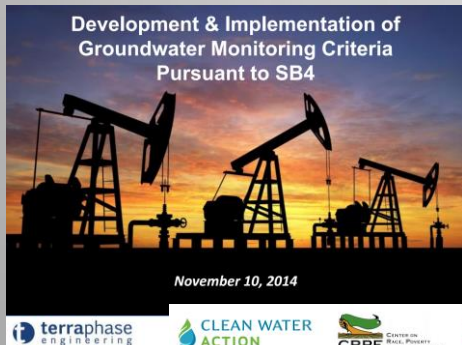
Environmental Justice
and Environmental
Perspectives

Andrew Grinberg - Clean Water Action
Sofia Parino- Center on Race Poverty and the Environment
Tom Williams – Sierra Club Angeles Chapter and Citizens Coalition for a Safe Community
Bill Allayaud – Environmental Working Group

Peer-Reviewed Literature

ENVIRONMENTAL Science & Technology

Viewpoint

pubs.acs.org/est

Suggested Reporting Parameters for Investigations of Wastewater
from Unconventional Shale Gas Extraction

Kyle J. Bibby,[†,‡] Susan L. Brantley,[§] Danny D. Reible,[||] Karl G. Linden,[⊥] Paula J. Mouser,[#]
Kelvin B. Gregory,[▽] Brian R. Ellis,[○] and Radisav D. Vidic*,[†]

Regional Scale Groundwater Monitoring

- **What should a regional program look like**
  - **Groundwater analysis**
  - **Groundwater monitor well design**
  - **Data accessibility**
  - **Limitations or exemptions?**

- **When and where should regional-scale monitoring be conducted**
  - Criteria for transition from local to regional monitoring?
  - Area prioritization for regional-scale monitoring?
  - Limitations or exemptions?

**Regional-scale groundwater monitoring targets
an oil & gas field or a groundwater basin**

Regional-scale Groundwater Monitoring: Documents

Science Assessments

USGS Conceptual Model

Taylor K. A., Fram M. S., Landon M. K., Kulongoski J. T. and Faunt C. C. (2014) *Oil, Gas, and Groundwater in California - a discussion of issues relevant to monitoring the effects of well stimulation at regional scales*., California Water Science Center, U.S. Geological Survey. Prepared in cooperation with the California State Water Resources Control Board.

CCST, LBNL and Pacific Institute (2014) Advanced Well Stimulation Technologies in California: An Independent Review of Scientific and Technical Information.,

Carbon sequestration

Contents lists available at ScienceDirect

International Journal of Greenhouse Gas Control

journal homepage: www.elsevier.com/locate/ijggc

Key factors for determining groundwater impacts due to leakage from geologic carbon sequestration reservoirs

Susan A. Carroll[a,*], Elizabeth Keating[b,1], Kayyum Mansoor[a,2], Zhenxue Dai[b,3], Yunwei Sun[a,4], Whitney Trainor-Guitton[a,5], Chris Brown[c,6], Diana Bacon[c,7]

[a] Lawrence Livermore National Laboratory, 7000 East Avenue, Livermore, CA 94550, United States
[b] Los Alamos National Laboratory, Bikini Atoll Road, SM 30, Los Alamos, NM 87545, United States
[c] Pacific Northwest National Laboratory, 902 Battelle Boulevard, Richland, WA 99354, United States

Literature

Groundwater

Issue Paper/

Groundwater Protection and Unconventional Gas Extraction: The Critical Need for Field–Based Hydrogeological Research

by R.E. Jackson[1], A.W. Gorody[2], B. Mayer[3], J.W. Roy[4], M.C. Ryan[3], and D.R. Van Stempvoort[4]

LLNL will provide expert advice on both design criteria and conceptual models for groundwater monitoring

- **Model groundwater monitoring criteria:**

  — LLNL **will recommend model criteria** to be considered for groundwater monitoring of current and past oil and gas field related activities on spatial scales from individual well to regional groundwater basin.

  —LLNL **will provide documentation to support the recommendations**

- **Conceptual regional model evaluation:**

  —LLNL **will review the State Water Board's conceptual model for regional groundwater monitoring** in areas of current and past oil and gas production.

  —The State Water Board has contracted the **US Geological Survey to develop a conceptual model for regional groundwater monitoring**

LLNL will be responsible for the recommendations delivered to the Water Board.

Conclusion

- **The intent of LLNL's expert advice is**

  —to provide scientifically-credible recommendations that are protective of groundwater, clearly written, and technically feasible

- **The State Board shall**

  —take into consideration the recommendations received, and

  —develop model groundwater monitoring criteria…

**LLNL makes recommendations.
The Water Board develops criteria & plans.**

Groundwater monitoring criteria (Sec 7f)

1. **An assessment of the areas to conduct groundwater quality monitoring** and their appropriate boundaries.

2. **A list of the constituents** to measure and assess water quality.

3. **The location, depth, and number of monitoring wells** necessary to detect groundwater contamination at spatial scales ranging from an individual oil and gas well to a regional groundwater basin including one or more oil and gas fields.

4. **The frequency and duration** of the monitoring.

5. **A threshold criteria** indicating a transition from well-by-well monitoring to a regional monitoring program.

6. **Data collection and reporting protocols.**

7. **Public access to the collected data**

These criteria will be developed over the coming year by the Water Board
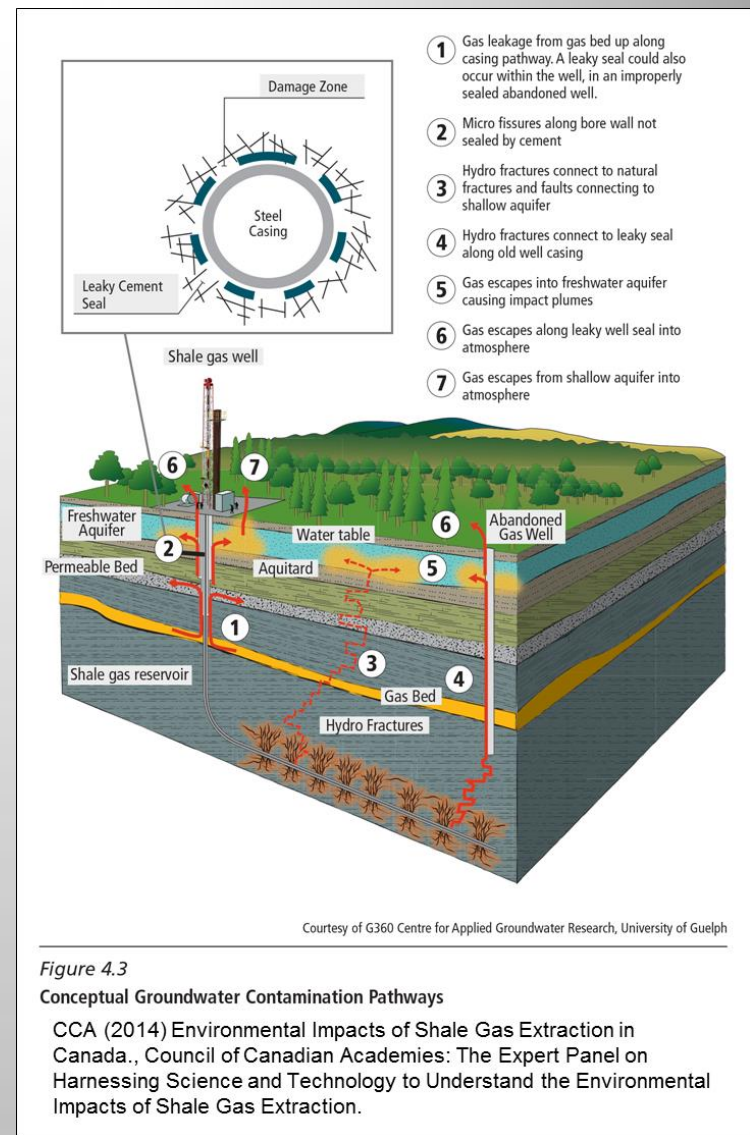
Groundwater monitoring factors (Sec 7g)

1. **The existing quality and existing and potential use** of the groundwater.

2. **Groundwater that is not a source of drinking water** consistent with USEPA's definition of an Underground Source of Drinking Water as containing less than 10,000 mg/L TDS, including exempt aquifers

3. **Proximity to human population**, public water service wells, and private groundwater use, if known.

4. **The presence of existing oil and gas production fields**, including the distribution, physical attributes, and operational status of oil and gas wells therein.

5. **Events, including well stimulation treatments and oil and gas well failures,** among others, that have the potential to contaminate groundwater; appropriate monitoring to evaluate whether groundwater contamination can be attributable to a particular event, and any monitoring changes necessary if groundwater contamination is observed.

Section 7g requires "event" monitoring and monitoring "protected" water

Contaminant pathways

Contamination Source/Pathway	Shallow	Intermediate, Deep
Surface operations (e.g. sumps)	X	
Waste solids disposal	X	
Wastewater disposal	X	X
Oil/gas well casing failure	X	X
Abandoned wells	X	X
Natural fractures & faults		X
Hydrofracturing		X

1. Gas leakage from gas bed up along casing pathway. A leaky seal could also occur within the well, in an improperly sealed abandoned well.
2. Micro fissures along bore wall not sealed by cement
3. Hydro fractures connect to natural fractures and faults connecting to shallow aquifer
4. Hydro fractures connect to leaky seal along old well casing
5. Gas escapes into freshwater aquifer causing impact plumes
6. Gas escapes along leaky well seal into atmosphere
7. Gas escapes from shallow aquifer into atmosphere

Courtesy of G360 Centre for Applied Groundwater Research, University of Guelph

Figure 4.3
Conceptual Groundwater Contamination Pathways

CCA (2014) Environmental Impacts of Shale Gas Extraction in Canada., Council of Canadian Academies: The Expert Panel on Harnessing Science and Technology to Understand the Environmental Impacts of Shale Gas Extraction.

Contaminant sources & pathways will be considered in developing monitor plan criteria

The plan

- **Use LLNL and LBL staff to develop background material to brief experts and support recommendations in final report.**

- **Convene experts for public meeting with input from stakeholders.**

- **Experts develop recommendations for criteria based on all input**

- **LLNL uses expert input to develop a draft report containing recommendations**

- **LLNL presents draft recommendations to Water Board of Directors**

- **LLNL submits final report**

The "experts" are not a panel – LLNL alone is responsible for the final report and recommendations.